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BIRDS AS DESTROYERS OF GRASSHOPPERS IN CALIFORNIA.

BY HAROLD C. BRYANT.

CONSIDERABLE evidence of the interrelations existing between bird and insect life has come to light in connection with investigations into the economic status of certain birds carried on under the auspices of the California State Fish and Game Commission and the University of California. Some of the best evidence came from an investigation of a grasshopper outbreak in the vicinity of Los Banos, Merced County, California. A part of the results of this investigation was published in the University of California 'Publications in Zoology,' volume 11, pages 1-20. In the present paper additional matter is combined with a part of that previously presented, the whole being now offered with a special view to the problem of insect destruction by birds in California.

Certain sections of California are annually troubled with grasshoppers, and there is seldom a year when they do not cause considerable damage to crops in some part of the state. Reports of damage caused by grasshoppers in 1912 first began to be received in June. The western part of Merced County, and parts of Kings and Kern Counties were most affected. In the vicinity of Los Banos, Merced County, where the investigation was carried on, grasshoppers give some trouble each year but their depredations in 1912 were more extensive than usual. On many of the ranches the entire summer crop of alfalfa was destroyed. The only control measure resorted to was burning over of pasture and alfalfa land. As most of the grasshoppers already had wings when the burning was done, the majority escaped unharmed. Garden truck and small trees in the infested areas were attacked by the pests. Corn, tomatoes, and even onions were stripped of every leaf. In many instances small shade trees, even including eucalyptus, were completely defoliated.

The species of grasshopper causing the damage was the differential grasshopper, *Melanoplus differentialis*. The only other species noted at the time were *Camnula pellucida*, *Conozoa behrensi*, and *Parapomala calamus*.

An estimate of the numbers per square yard in the infested areas was obtained by counting the numbers disturbed by the observer at each step. Little damage could be noted where grasshoppers were less than fifteen to the square yard. Where damage was greatest alfalfa fields averaged about twenty-five to the square yard. In some pasture land along the irrigation canals the number was estimated at thirty per square yard.

This will give the reader an idea of the conditions existing at the time observations hereafter recorded were made.

The neighborhood of Los Banos, largely due to the great irrigation system and to the large amount of land which has been 'swamped,' supports a very large bird population. Water birds and shore birds are very abundant along the canals and in the marshes, whereas the pasture lands, the alfalfa, and the trees, furnish food and cover for many land birds. During a week's stay, July 10 to 17, 1912, twenty-two species of water and shore birds were recorded and forty species of land birds. Censuses taken indicated that the Bicolored Redwing was the most abundant bird and that the Cliff Swallow, Barn Swallow, Western Meadowlark, Linnet, Western Kingbird, and California Shrike, listed in the order of their abundance, were also common.

Observation showed that the following species of birds were feeding on grasshoppers. Only those birds *actually seen* with grasshoppers in their bills were recorded.

Western Meadowlark, *Sturnella neglecta*.

Bicolored Red-wing, *Agelaius phœniceus californicus*.

Brewer's Blackbird, *Euphagus cyanocephalus*.

Bullock's Oriole, *Icterus bullocki*.

Arkansas Kingbird, *Tyrannus verticalis*.

California Shrike, *Lanius ludovicianus gambeli*.

English Sparrow, *Passer domesticus*.

Although observation in the field furnishes some evidence as to the kinds of birds feeding on an insect and the quantity consumed, yet it is on stomach examination that we must depend for accurate evidence as to the numbers of insects taken. In this instance a determination of the numbers of grasshoppers taken by the bird was made easy because of the presence of the mandibles of the insects — hard parts which remained undigested. Experiments

TABLE SHOWING STOMACH CONTENTS OF BIRDS EXAMINED.

Species	Number of stomachs	Kind of field	Time of day	Per cent animal food	Per cent vegetable food	No. of grasshoppers	Per cent of grasshoppers
Great Blue Heron.....	1	Marsh	Found dead	100	—	—	[2 gophers]
Killdeer.....	1	Pasture	10:10	100	—	11	100
Anthony's Green Heron.....	1	Pasture	4:00	100	—	14	15
Burrowing Owl.....	1	Pasture	12:30	100	—	28	90
Arkansas Kingbird.....	2	Pasture and alfalfa	2:00	100	—	5	67.5
Black Phoebe.....	1	Alfalfa	10:30	100	—	3	50
California Horned Lark.....	2	Pasture	12:30	52.5	47.5	5	7.5
Yellow-headed Blackbird.....	1	Tules	2:00	15.	85.0	—	—
Bicolored Red-wing.....	4	Alfalfa and pasture	8-4	94.0	6.0	38.0	81.2
Tricolored Red-wing.....	1	Alfalfa	4:00	97.0	3.0	6.0	97
Western Meadowlark.....	5	Pasture and alfalfa	8-12	99.2	.8	80.0	96.2
Bullock's Oriole.....	2	Orchard	9:50	98.0	2.0	30.0	92.0
Brewer's Blackbird.....	1	Pasture		95.0	5.0	3.0	80.0
English Sparrow.....	2	Wheat field	4:00	3.5	96.5	1.0	2.0
Cliff Swallow.....	4	Pasture	8, 4	100.0	—	2.0	7.5
Barn Swallow.....	1	Pasture	12:30	100.0	—	—	—
California Shrike.....	2	Pasture and alfalfa	10, 11	100.0	—	8.0	47.0

by other investigators as well as some performed by the writer show that insects such as grasshoppers are digested by birds in from three to four hours. Consequently the number of grasshoppers destroyed each day must be at least three times the number found in a stomach.

The following table gives the results of the stomach examinations. In spite of the comparatively few stomachs of each species examined the results should give a fairly accurate idea of the extent to which birds in the infested areas were feeding on grasshoppers.

Considering the capacity of the bird, the Burrowing Owl (*Speotyto cunicularia hypogæa*) must be considered the most efficient destroyer, twenty-eight grasshoppers having been found in the one stomach examined. Blackbirds and Meadowlarks however, exceeding in numbers of individuals, were probably doing the most effective work.

The comparative destruction of grasshoppers per day by single individuals and by the total number of each species is crudely

COMPARATIVE DAILY DESTRUCTION OF GRASSHOPPERS BY BIRDS.

Species	Average number of grasshoppers per day by	
	one bird	total individuals of species
Anthony's Green Heron (<i>Butorides virescens anthonyi</i>)	42	1050
Killdeer (<i>Oxyechus vociferus</i>)	33	5445
Burrowing Owl (<i>Speotyto cunicularia hypogæa</i>)	84	1260
Arkansas Kingbird (<i>Tyrannus verticalis</i>)	8	1280
Black Phoebe (<i>Sayornis nigricans</i>)	9	180
California Horned Lark (<i>Otocoris alpestris actia</i>)	8	88
Bicolored Red-wing (<i>Agelaius gubernator californicus</i>)	29	78,590
Western Meadowlark (<i>Sturnella neglecta</i>)	48	24,720
Bullock's Oriole (<i>Icterus bullocki</i>)	45	4050
Brewer's Blackbird (<i>Euphagus cyanocephalus</i>)	9	225
English Sparrow (<i>Passer domesticus</i>)	2	100
Cliff Swallow (<i>Petrochelidon lunifrons lunifrons</i>)	3	2265
California Shrike (<i>Lanius ludovicianus gambeli</i>)	12	1200
Destruction per square mile by total bird population		120,453

represented in the table on p. 171. It should be here stated that censuses of the bird population by species were taken and are used in this calculation. The comparative numbers of the different species were calculated by averaging the two censuses taken and using the average per square mile as a multiplier.

Although the table is probably far from accurate, yet it gives some idea of the comparative destruction afforded by the different species. It will be noted that such birds as the Bicolored Red-wing and the Western Meadowlark, birds of small capacity, far outrank in destructiveness birds with large capacity, because of their greater numbers. Red-wings, Meadowlarks, Orioles, Kingbirds, and Shrikes appeared to be feeding almost wholly upon grasshoppers. Probably more than three-fourths of all the destruction by birds was accomplished by these five species. It should be of interest to note that these are mainly birds against which complaint is made upon the score of crop destruction. Even though the Bicolored Red-wing averaged but nine grasshoppers per bird in those examined, yet, on account of the numbers of individuals, it must be considered the most valuable destroyer. The one stomach of a Brewer's Blackbird examined probably does not demonstrate the true character of this bird's food at this time, for in other instances this blackbird has been found to be more insectivorous than the Bicolored Red-wing. The average Western Meadowlark must have consumed at least fifty grasshoppers a day.

Certain birds examined and found to contain but few grasshoppers doubtless fed to a larger extent on these insects when they were of smaller size. The swallows, for instance, owing to their small size, were unable to eat a large grasshopper. If the investigation could have covered the entire time of the outbreak, it would probably have been found that certain birds were far more efficient destroyers when the insects were small than when they became larger.

Fortunately some material collected at Los Banos the same month in 1911 was available. This afforded a comparison of the food of the Western Meadowlark and the Bicolored Red-wing in two successive years. As grasshoppers were less numerous in the summer of 1911, it has been possible to obtain information as to the comparative destruction by these birds when grasshoppers were in

relatively normal numbers and when they were in abnormal numbers. A glance at the following table will show the percentages of the different kinds of food taken and the average number of grasshoppers taken per bird.

COMPARATIVE DESTRUCTION OF GRASSHOPPERS IN TWO SUCCESSIVE YEARS.

WESTERN MEADOWLARK.

Number of birds	Date	Per cent animal food	Per cent vegetable food	Average number grasshoppers per bird	Total per cent grasshoppers
10	July 11, 22, 1911	99.0	1.0	7	83.1
5	July 15, 17, 1912	99.2	.8	16	96.2

BICOLORED RED-WING.

6	June 22; July 6, 1911	83.5	16.5	2	37.0
4	July 13, 16, 1912	96.0	4.0	9	81.2

Meadowlarks took very nearly the same percentage of animal food each year, showing that at this time of year the bird is almost wholly insectivorous. The availability of grasshoppers as a diet appears to have influenced the birds taken in 1912 for they averaged sixteen grasshoppers apiece as against seven taken by the birds collected in 1911. A greater difference in kind of food is to be noted in the Bicolored Red-wing.

As the number of grasshoppers in 1911 compared to the number in 1912 is not definitely known, it is impossible to say whether these birds changed their food habits in direct proportion to the number of grasshoppers or whether they were taken in an unequal proportion due to the extreme availability of the insects in 1912. The fact remains, however, that Meadowlarks and Bicolored Red-wings, and probably all other insectivorous birds, not only took greater numbers of grasshoppers when they were abnormally abundant, but also forsook certain usual articles of diet such as weed seeds and beetles, thus causing an increased percentage of grasshoppers to be taken as food.

One of the most interesting things which came out in the investigation at Los Banos was the evidence that at least one of the

shore birds and one of the herons had turned their attention to the grasshoppers. One hundred per cent of the food of a Killdeer was made up of grasshoppers, eleven having been eaten. The Killdeer being a common bird in the locality and having a greater capacity than smaller birds must be considered an effective destroyer. An Anthony's Green Heron collected along a canal contained fourteen grasshoppers.

Such then, are the conditions to be expected during an outbreak of grasshoppers. Birds flock to infested areas and also change their food habits to meet the abundance of a particular kind of food, thus doubly increasing their efficiency in helping to bring back normal conditions.

Let us now compare conditions to be expected in localities where grasshoppers exist in more nearly normal numbers. Since birds which forage on the ground feed to an especially large extent upon grasshoppers, we will depend upon the analysis of the food of such a bird for evidence. As an illustration of this type there is no better bird than the Western Meadowlark.

The Eastern Meadowlark is noted as a bird which feeds extensively on grasshoppers, 29 per cent of the food for the year being made up of these insects. Beal (U. S. Dept. Agric., Div. Biol. Surv., Bull. 34, p. 66) has pointed out that the eastern bird surpasses the western in the number of grasshoppers destroyed. He further states that nearly every species of bird in the east eats a larger percentage of these insects than does the related species on the Pacific coast in spite of the fact that in the west grasshoppers are available for a longer period each year.

Further evidence furnished by the examination of nearly two thousand stomachs of Western Meadowlarks taken in all parts of California and in every month of the year has shown that the western bird, although not equaling the record of the eastern bird, in reality takes larger quantities of grasshoppers than was at first supposed.

Fourteen and two tenths per cent of the total food of the Western Meadowlark for the year in California is made up of grasshoppers. An additional 5.2 per cent is made up of crickets (*Gryllus*) and an additional .9 per cent of Jerusalem crickets (*Stenopelmatus*). Five hundred and eighty-seven or 30.5 per cent of the nineteen hundred

and twenty Meadowlarks examined had eaten grasshoppers and an additional three hundred and thirty-nine had taken crickets.

The number of grasshoppers taken by Western Meadowlarks was found to vary greatly in different parts of the state. Evidently the number taken was governed by the availability of the insect. Meadowlarks collected at Eureka, Humboldt County, had eaten but very few and these had been taken in but three months of the year. Birds collected in the Sacramento and San Joaquin valleys had consumed large quantities. Of Meadowlarks collected at Red Bluff, Tehama County, over 28 per cent of the food for the year was found to be made up of grasshoppers and 27.5 per cent of the food for the year of Meadowlarks collected at Newman, Stanislaus County.

Birds in the vicinity of Los Banos, Merced County, must consume a similar amount of grasshoppers for during the five months, March to July inclusive, a time of year when these insects are not found in maximum numbers, Meadowlarks from this vicinity showed that 25.2 per cent of their food was made up of these insects.

Some interesting evidence of the change of food habits to meet the abundance, or better the availability, of grasshoppers is furnished by the results of an examination of the stomach contents of Meadowlarks collected in 1911 and in 1912 at Newman, Stanislaus County. Sixty per cent of all the birds of this species collected in this locality during the year 1911 had eaten grasshoppers and 27.5 per cent of the food taken was made up of these insects. In 1912 when grasshoppers were far more numerous, nearly 42.5 per cent of the food of the same number of birds taken during the same month was made up of grasshoppers.

A similar change of food habits to meet local conditions was exhibited by Meadowlarks collected at Hollister, San Benito County, in 1911. In this locality over 18 per cent of their food was made up of crickets (*Gryllus* sp.) and but 7 per cent of grasshoppers. In the month of August only did grasshoppers exceed crickets in the food and then only by one per cent.

The highest percentage of grasshoppers taken by Western Meadowlarks in any one month was by four birds collected at Salinas, Monterey County, in June, 1911, 93.7 per cent of all their

food being made up of grasshoppers. Four Inyo County Meadowlarks taken in August showed that 82.5 per cent of their food was made up of these insects.

Meadowlarks taken at El Toro, Orange County, showed one of the best records. Grasshoppers had been taken every month of the year and made up very nearly 42 per cent of the food. As an average of a dozen birds collected each month during a year was available from this locality this must give a fair idea of the extent to which Western Meadowlarks feed upon grasshoppers in this vicinity; viz.

TABLE SHOWING NUMBERS AND PERCENTAGES OF GRASSHOPPERS CONSUMED BY WESTERN MEADOWLARKS TAKEN IN THE VICINITY OF EL TORO, ORANGE COUNTY, CALIFORNIA.

1911	Number of birds	Number of grasshoppers	Average number of grasshoppers per bird	Average percentage of grasshoppers
June	13	53	4.0	43.2
July	7	59	8.4	77.5
August	19	314	16.5	93.9
September	6	75	12.5	96.3
October	13	122	9.3	61.9
November	8	115	14.3	66.6
Totals and averages	66	738	10.1	73.3

The average destruction per day can be obtained by multiplying the figures of the table by three. The numbers given are the numbers actually found in the stomachs. The fact that sixty-six Meadowlarks taken in the six months when grasshoppers are abundant, and in a locality where outbreaks are almost unknown, averaged ten grasshoppers apiece or thirty a day, furnishes convincing evidence of the large toll exacted by this bird. The fact that 96.3 per cent of the food of six birds taken in September was made up of grasshoppers is also significant of a preference for this insect.

It can be seen therefore, that no small part of the food of the Western Meadowlark is made up of grasshoppers. In fact the only

other insect making up a larger percentage of food is the ever-present beetle.

The individual records of meadowlarks show that the numbers of grasshoppers taken is very large as well as the percentage taken as food. From fifteen to thirty average-sized grasshoppers are usually consumed every four hours. Meadowlarks collected near Stockton, San Joaquin County, March to April, 1911, averaged nearly six grasshoppers apiece, thus showing a daily average of over seventeen. The same birds averaged ten crickets per day. Grain, weed seeds, and other insects made up the larger part of the food. A young meadowlark was fed 28 small grasshoppers (half an inch in length) at one meal. The capacity for the destruction of grasshoppers is therefore very great. The extent to which this capacity is used is dependent on the availability of the insect.

Such is some of the evidence regarding the destruction of grasshoppers by birds in California. It allows of the conclusion that birds are really a significant agent in the destruction of these pests. It does not allow of the conclusion that they can be relied upon to limit their numbers below the point where damage can result. Man demands too great a readjustment of natural conditions to permit of complete dependence on the natural order of things. But because artificial means of controlling insect pests must be used, the value of a knowledge of the interrelations of organisms is in no way lessened.

In a study of this kind we can at best but discover the more obvious relations between birds and insects. Occasionally we can infer that certain interrelations exist which are not capable of being demonstrated by direct evidence. For instance: The failure of birds to check an insect outbreak after insects have appeared in abnormal numbers is evident to all. The success in preventing insects from becoming abnormally abundant is not apparent. In fact no absolute proof of their good work in this connection is obtainable. It must simply be inferred from data regarding the food of birds and their relation to insects when they appear in abnormal numbers, that the regulative influence exerted at times when normal conditions exist is just as important if not more important than their influence under abnormal conditions. It seems safe to conclude that the regulative influence exerted by birds keeps pace with the fluctuations of insect life.